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ANALYSIS OF SULFUR DIOXIDE EXCESS AT GALLATIN STATION 1 ON APRIL 3-4, 1981

AIR RESOURCES PROGRAM

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Office of Natural Resources

ANALYSIS OF SULFUR DIOXIDE EXCESS AT GALLATIN STATION 1 ON APRIL 3-4, 1981

Prepared by

Kenneth G. Wastrack

Air Resources Program

Muscle Shoals, Alabama

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ANALYSIS OF SULFUR DIOXIDE EXCESS AT GALLATIN STATION 1 ON APRIL 3-4, 1981

Scope and Objectives

On April 3-4, 1981, sulfur dioxide (SO_2) levels in excess of the primary National Ambient Air Quality Standard (NAAQS)[1] were measured at monitoring station 1 near Gallatin Steam Plant. SO_2 concentrations exceeding the 24-hour primary standard of 0.14 parts per million (ppm) were measured for the 24-hour period ending at 1500 CST on April 4, 1981 (0.15 ppm). There have been no other nonoverlapping excesses at this station thus far during 1981. Therefore, this excess does not represent a violation of the primary standard.

This report examines the physical and environmental circumstances associated with the April incident, documents these circumstances as completely as practical, and determines the sources in the vicinity of station 1 that were contributors to the incident. Data bases used during this investigation included: TVA meteorological and air quality data from the Gallatin Steam Plant monitoring network, National Weather Service (NWS) data, topographic maps, source emission data (obtained from the State of Tennessee), and Gallatin Steam Plant operational data. This report presents and evaluates all available data and information related to the April 3-4 measurements.

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1. For sulfur dioxde, the primary standard (for protection of public health) is 0.14 ppm for a 24-hour average; the secondary standard (for protection of public welfare) is 0.50 ppm for a 3-hour average. These standards are not to be exceeded more than once per year.

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Physical and Environmental Factors

The relevant physical and environmental factors are examined to identify conditions surrounding the excess measured at station 1.

Gallatin Steam Plant Vicinity

Gallatin Steam Plant is located on the northeast shore of Old Hickory Lake (Cumberland River) in Tennessee, about 10 kilometers (km) southeast of the town of Gallatin and approximately 40 km east-northeast from the center of Nashville. The steam plant is located on a bend in the river and is almost completely surrounded by water. Surrounding terrain is generally flat, with a few hills, and no significant terrain features, within 10 km that might influence plume dispersion.

Ambient Air Monitoring

Air Quality Monitoring--TVA operates a network of six ambient air quality monitors in the vicinity of Gallatin Steam Plant (figure 1, table A-1). At five of these stations (station 3 excluded), SO_2 is continuously monitored coulometrically with a Philips PW-9700 ambient monitor.

On April 3-4, 1981, 24-hour average SO_2 concentrations of 0.15 ppm were recorded at station 1 for the period ending at 1500 CST on April 4, 1981. This represents an excess, but not a violation, of the primary standard.

SO_2 concentrations for all other stations in the Gallatin network for April 3-4, 1981 did not exceed 0.03 ppm hourly average. All pertinent SO_2 data are listed in appendix A.

Monitoring Station 1 Description--Monitoring station 1 is located in a rural area 2.9 km north of the steam plant at an azimuth of 5°. The site is a pasture with a paved road 35 meters (m) to the west. Within 200 m, surrounding the site, there is no heavy or light industry, housing is light, and land use is 30 percent forest, 50 percent pasture and 20 percent other. This site meets State and local Air Monitoring Station (SLAMS) minimum distance criteria for SO_2 monitoring.

Several TVA calibrations and a State of Tennessee audit were performed on the SO_2 monitor at station 1 during February-April 1981. These indicated that the SO_2 monitor was reporting concentrations approximately 3 to 9 percent higher than actually occurred (for monitor reading = 0.15 ppm), within acceptable accuracy limits.

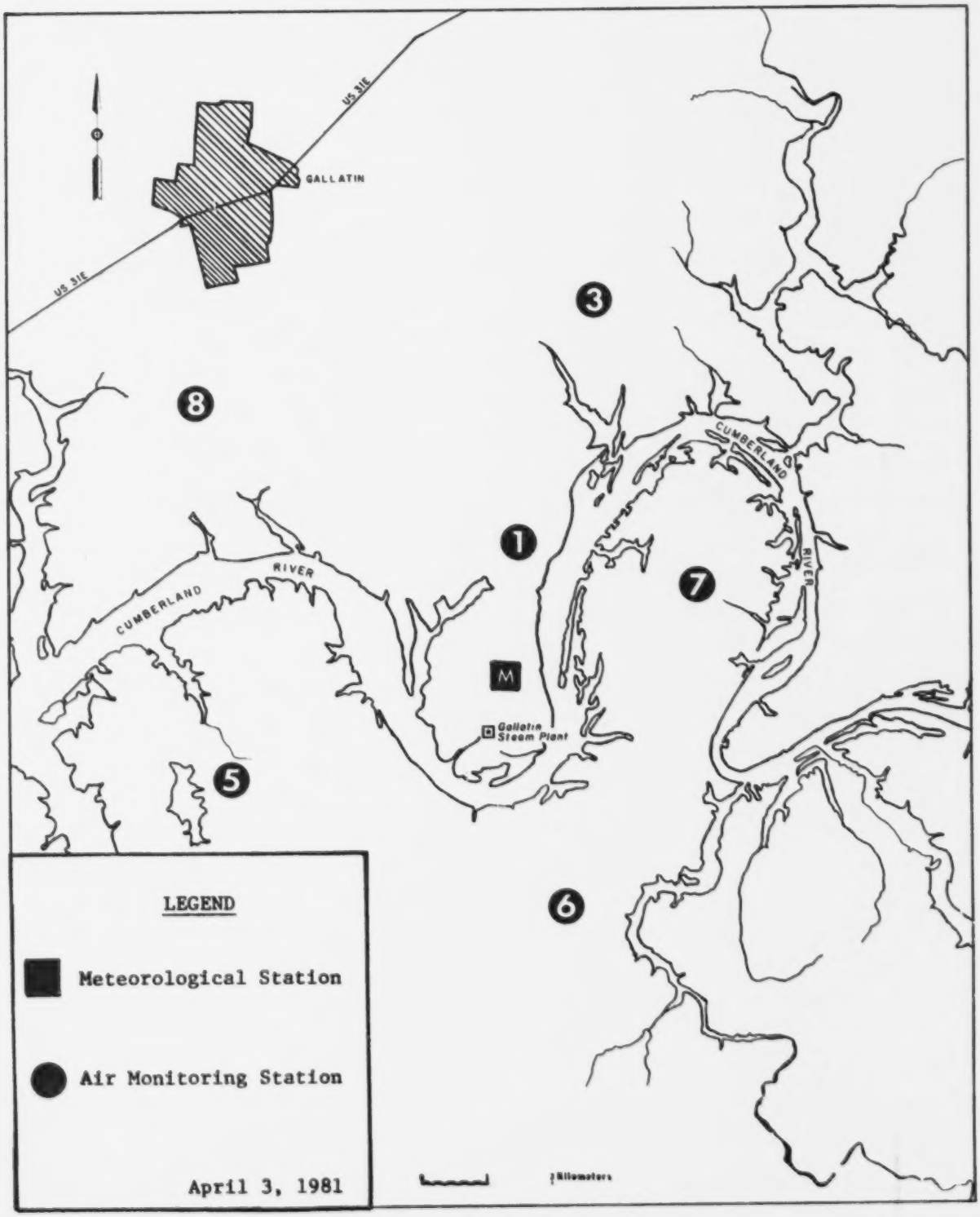

Figure 1. GALLATIN STEAM PLANT - AIR MONITORING NETWORK

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Meteorological Monitoring--A TVA-operated meteorological tower is located 1.1 km north of the steam plant. Temperature is measured at two levels (10 m and 61 m), and wind speed/direction are measured at one level (61 m). All data are averaged hourly.

Relevant meteorological tower data are listed in appendix B. During the incident period, the tower top (61 m) wind direction ranged from 177° to 200°, almost directly towards monitoring station 1. Wind speeds at the 61 m level exceeded 6.8 meters per second (m/s) throughout the period.

Survey of SO_2 Emission Sources

Relevant SO_2 emissions data, from sources near station 1, are listed in appendix C.

Gallatin Steam Plant--TVA's Gallatin Steam Plant is the largest source of SO_2 in the vicinity. The steam plant has two 300-megawatt (MW) rated units and two 328-MW rated units, which emit combustion gases through two 152-m stacks. At normal full load of 1,106 MW, the steam plant emits approximately 5,400 grams per second (g/s) of SO_2, assuming 2.8 percent sulfur coal, or about 4.4 pounds of SO_2 per million Btu (the current emission standard is 5.0 pounds of SO_2 per million Btu heat input).

At the time of the excess, Gallatin Steam Plant was operating at approximately 487 MW (39 percent of rated capacity). SO_2 emissions were approximately 2,488 g/s (35 percent of expected emissions at rated capacity)--well below what might normally be expected.

Other Nearby Sources--There are several SO_2 emission sources within 10 km of Gallatin Steam Plant, generally located in Gallatin and Lebanon, Tennessee. However, these sources generally have SO_2 emissions too small to significantly influence monitoring station 1, or were not upwind from the monitor to cause high SO_2 concentrations.

Distant SO_2 Sources--The metropolitan Nashville area (25-50 km southwest of the steam plant) contains numerous emission sources. These sources (and other sources beyond 10 km) are generally too distant (and not upwind) to significantly influence monitoring station 1.

Meteorological Factors

The available meteorological data related to this incident are included in appendix B. They consist of NWS surface weather maps, NWS upper-level (850 mb) charts, TVA meteorological tower data from Gallatin Steam Plant, and NWS upper level temperature/winds data from Nashville, the closest upper air observing station. Basic dispersion parameters related to this incident were derived from these records and charts. Atmospheric processes occurring on the following scales were considered: (1) the scale depicted by the synoptic weather maps; (2) a mesoscale which is affected by surface terrain features that modify wind and thermal fields in the free atmosphere; and (3) a microscale which commonly includes 10 to 15 m above the earth's surface. Events at these separate scales both overlap and interact.

A low pressure system was centered over the upper Midwest near the intersection of Iowa, Minnesota, and Wisconsin. A cold front extended south from this system from Chicago through Illinois, Missouri, Arkansas, Texas, and into northern Mexico. This cold front induced strong and persistent wind flow from the southwest over the Tennessee Valley region.

Upper-air conditions over Gallatin Steam Plant were derived from upper-level measurements over Nashville Metropolitan Airport, approximately 35 km southwest of the steam plant. The wind and temperature structure was quite uniform throughout the period of high SO_2 concentrations. Winds were from the south and south-southwest with strong speeds (up to 32 m/s). Atmospheric stability was generally neutral. These weather conditions would produce persistent coning-type plume dispersion conditions.

Nature of the Excess

There are several forms an excess might take. An excess at one site might represent the maximum of elevated concentrations observed at all or a number of sites in a network. Alternatively, it could be an isolated event which affects one monitor, but not any of the others. The persistence of high concentrations during an excess must also be considered. The nature of an excess, i.e., the spatial distribution and persistence of high concentrations, is important in identifying sources which might be responsible.

The following observations about the nature of the excess can be made based on a review of network ambient air monitoring data and of the actual strip chart recording during the excess.

1. No other station in the Gallatin monitoring network measured any SO_2 above background levels. This indicates an isolated nearby source since a distant source would have impacted several monitors.
2. The strip chart trace was very jagged with sharp changes in concentrations occurring within a few minutes. This trace is characteristic of a narrow plume alternately impacting and moving off the monitor due to fluctuations in wind speed and direction.
3. SO_2 concentrations were closely related to wind conditions. Highest concentrations (greater than 0.15 ppm hourly average) generally occurred when wind speeds were above 9 m/s and hourly average wind directions were 181^{o}-189^{o} (61 m level). Concentrations dropped significantly when wind conditions were outside these limits. This indicates a persistant impact from a single nearby source.

These observations indicate that monitoring station 1 was probably influenced by a large, isolated, nearby SO_2 emission source. Distant emissions (greater than 10 km away) were not a significant factor in the excess.

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Discussion of Excess

In the previous section, meteorological and other factors important to determining the cause of the excess were examined. In this section, the specific circumstances related to the excess will be discussed.

Probable Emission Source

A pollution rose[3] for station 1 during the high SO_2 concentration period (figure 2) indicates that the source responsible for the excess was probably located to the south or south-southwest from station 1. Gallatin Steam Plant is the only SO_2 emission source in that direction, both large enough and close enough to monitoring station 1, to cause the excess observed.

Description of Excess

High wind speeds associated with neutral atmospheric stability during the April 3-4, 1981 period resulted in coning-type dispersion conditions. Near constant wind directions during the same period carried the plume continuously over a sector about 25^{o} wide. The gustiness of the winds (characteristically present with the high wind speeds observed in this region), and slight variations in wind directions are the likely cause of the very jagged strip-chart trace observed during the incident. Low exit velocities during the period, coupled with the high wind speeds may have resulted in an initial lowering of the plume because of stack downwash.

In summary, high persistent wind speeds during neutral atmospheric stability transported the plume over a relatively narrow sector for more than 24 hours. The high wind speeds resulted in low plume rise (with possibly some stack downwash) that caused high SO_2 concentrations sufficient to produce an excess. This is confirmed by dispersion modeling results (appendix D).

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3. A pollution rose is a graphical display of the frequency that various combinations of wind direction and pollutant levels occur.

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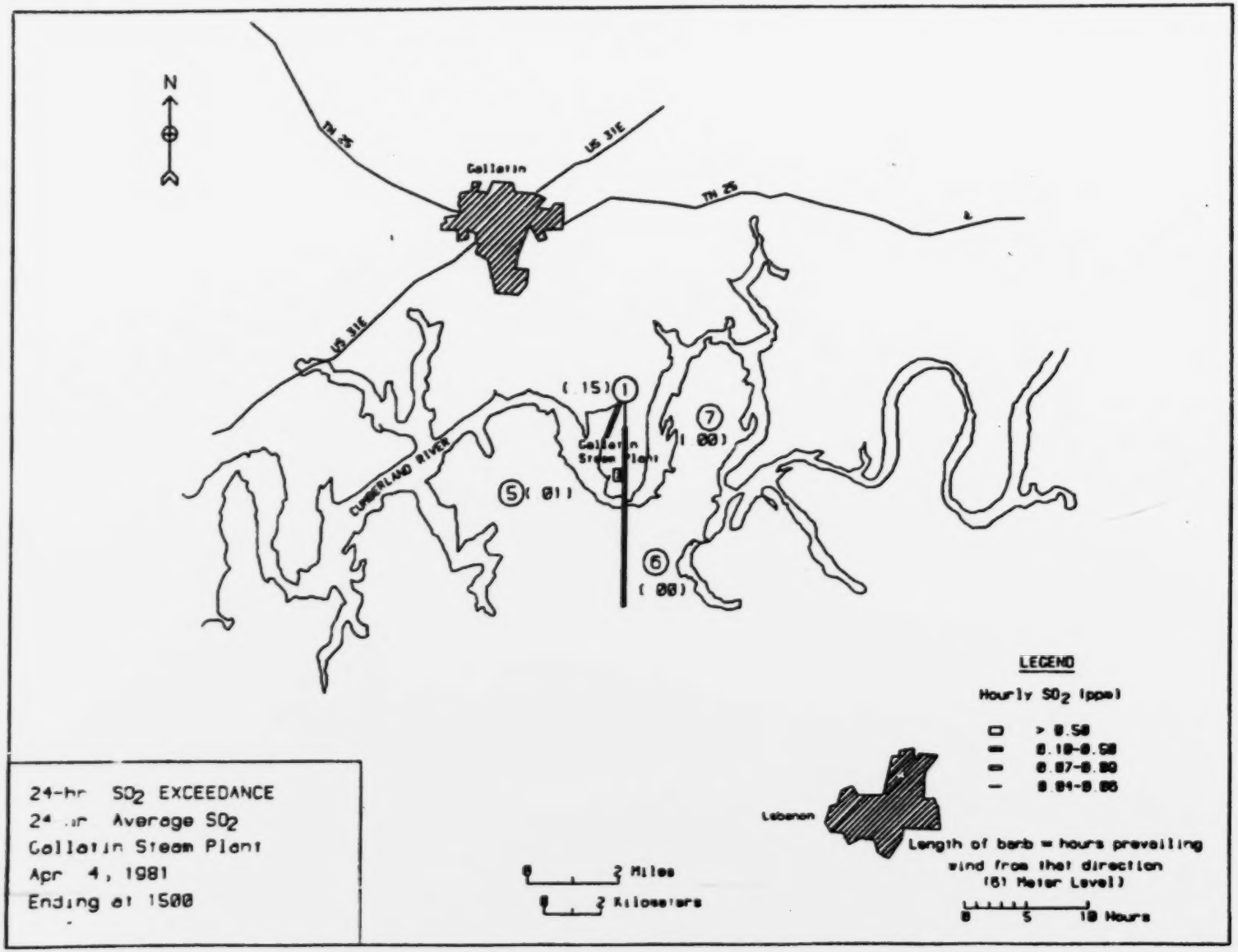

Figure 2. GALLATIN STEAM PLANT - POLLUTION ROSE MAP

Possibility of Recurrence

Gallatin Steam Plant was in compliance with applicable SO_2 emission standards, so an excess of the 24-hour standard was not expected. Because of possible adverse environmental consequences and actions TVA might need to take to prevent future excesses, it is important to determine if a recurrence is likely.

Meteorological Conditions

The 1-hour average wind speed when high SO_2 concentrations were measured (greater than 0.100 ppm) was above 9.0 m/s. During the 48 hours of April 3-4, 1981, 1-hour average winds above this speed occurred during 27 hours.

An analysis of five years of meteorological data from Gallatin Steam Plant (1976-1980) showed that nonoverlapping 48-hour periods containing wind speeds greater than 9.0 m/s occur approximately 54 times per year. The average 48-hour period contains less than 10 hours of winds above 9.0 m/s, while less than two 48-hour periods (1.6 periods) per year contain more than 25 hours of winds above this speed. Therefore, high wind speed conditions similar to those of April 3-4, 1981 can be expected to occur approximately once or twice per year.

One other factor must be considered in determining the possibility of recurrence of the April 3-4, 1981 conditions. Winds measured during the period of high SO_2 concentrations were extremely persistent, with a persistence, from 1200 CST on April 3 to 1700 on April 4, 1981, of 99.5 percent.[4] Of similar cases identified, none had persistency as high as the incident on April 3-4, 1981 (table 1). Therefore it is unlikely that similar conditions will occur more than once per year, on the average.

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4. Persistency = $100 \times \frac{L_R}{\Sigma L_I}$

were: L_R = Length of resultant vector produced by vector addition of all individual wind vectors during the period.

ΣL_I = Sum of lengths of individual component wind vectors during the period.

Table 1

WIND CONDITIONS SIMILAR TO APRIL 3-4, 1981*

(1976-1980)

- 2200 CST = February 20, 1976 to
  0800 CST = February 22, 1976
  Persistence = 61.0%

- 2100 CST = February 21, 1977 to
  2200 CST = February 24, 1977
  Persistence = 84.0%

- 1100 CST = March 27, 1977 to
  2400 CST = March 28, 1977
  Persistence = 99.0%

- 2300 CST = December 4, 1977 to
  1900 CST = December 6, 1977
  Persistence = 72.8%

- 1900 CST = January 25, 1978 to
  2200 CST = January 26, 1978
  Persistence = 92.6%

- 0100 CST = December 24, 1979 to
  1900 CST = December 25, 1979
  Persistence = 66.3%

- 0100 CST = April 14, 1980 to
  1700 CST = April 15, 1980
  Persistence = 93.5%

*Wind conditions were considered similar if wind speed exceeded 9 m/s for at least 25 hours with a 48-hour period. The start of a period was the first hour with wind speed exceeding 9 m/s, while the end of a period was the last hour with wind speed exceeding 9 m/s.

In summary, the wind conditions related to the April 3-4, 1981, incident are extremely unusual. Recurrence of similar meteorological conditions can be expected to occur no more than once per year and probably less frequently than that.

Plant Operating Conditions

Gallatin Steam Plant SO_2 emissions at capacity are expected to be 7,135 g/s. The average SO_2 emissions of 2,488 g/s, during the excess period, were only 35 percent of this value. The extent to which plant generation levels contributed to this incident is uncertain. If the plant had been operating at a higher load, plume rise would have been greater and adverse aerodynamic effects would have been less pronounced. The meteorological conditions on April 3-4, 1981 were the primary cause of the excess, and probably would have produced high ground-level concentrations for the entire range of expected SO_2 emissions.

Likelihood of Recurrence

The primary cause of the SO_2 concentrations observed on April 3-4, 1981, was the long duration of extremely persistent wind directions. Had the wind not been as persistent, it is unlikely that high concentrations would have occurred, regardless of steam plant SO_2 emissions, since the plume would have dispersed over a wider area. Therefore, a similar incident can be expected only when wind persistence conditions are similar--no more than once per year.

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Conclusions

1. Gallatin Steam Plant was the principal contributor to the 24-hour SO_2 excess measured at station 1 on April 3-4, 1981.
2. Gallatin Steam Plant had SO_2 emission of approximately 4.4 $lb/10^6$ Btu at the time the excess occurred.
   a. Average generation was 487 MW, approximately 39 percent of capacity.
   b. SO_2 emissions were approximately 35 percent of expected emissions at capacity.
3. This excess was primarily due to highly unusual meteorological conditions. The conditions related to this excess occur rarely at Gallatin Steam Plant (less than once per year, based on a 5-year data sample).

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APPENDIXES

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Appendix A

AIR MONITORING DATA

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Table A-1

AIR MONITOR DESCRIPTIONS

GALLATIN STEAM PLANT

APRIL 3-4, 1981

Monitor Number	Location From Gallatin Steam Plant		Pollutants Measured[a]
	Azimuth (°)	Distance (km)	
1	4	2.9	SO_2, TSP
3	13	6.8	TSP
5	261	3.8	SO_2, TSP
6	159	3.2	SO_2, TSP
7	59	3.7	SO_2
8	318	6.4	SO_2, TSP

a. SO_2 = Sulfur Dioxide

TSP = Total Suspended Particulate

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Table A-2

AMBIENT SO_2 CONCENTRATIONS - APRIL 3, 1981

GALLATIN AIR MONITORING NETWORK

[redacted] PLANT — [redacted] VALLEY AUTHORITY — [redacted] VALIDATED

STA ID 11 — AMBIENT AIR CONCENTRATIONS (PPM)

81103 04/03/81 (NOVA)

PREV 4D	WIND SPEED	SO2 PEAK	SO2 AVG	SO2 PEAK	SO2 AVG	SO2 PEAK	SO2 AVG	SO2 PEAK	SO2 AVG	SO2 PEAK	SO2 AVG	SO2 PEAK	SO2 AVG	
PERD	DIR	DIR	STA 1	STA 1	STA 7	STA 7	STA 6	STA 6	STA 5	STA 5	STA 4	STA 4	STA 8	STA 8	PERD
ENDG			(004)	(184)	(056)	(239)	(159)	(339)	(261)	(861)	(340)	(160)			ENDG
TCST)	DIED	DIED	AA	BA	AG	BG	AF	BF	AE	BE	AH	BH			TCST)
0100	193	15.1					.020	.010			.010				0100
0200	182	12.5							.010						0200
0300	184	14.7													0300
0400	170	14.3													0400
0500	181	10.3													0500
0600	181	10.3													0600
0700	184	12.5													0700
0800	193	17.2	.010												0800
0900	185	13.8	.420	.100							.010	.010			0900
1000	191	15.2	.360	.070			55 IN	92 IN			.010	.010			1000
1100	190	13.6	.520	.070			.010	.010	.010		.020	.010			1100
1200	189	20.9	.710	.170			.010		.010	.010	.020				1200
1300	189	21.1	.360	.090			.010		.010	.010					1300
1400	188	21.2	.410	.120			.010		.010	.010					1400
1500	182	20.9	.530	.100			.010		.010	.010					1500
1600	181	21.8	.300	.180			.010		.010	.010					1600
1700	161	24.4	.600	.140	.010	.010	.010	.010	.010	.010					1700
1800	177	20.6	.230	.040			.010	.010	.010	.010					1800
1900	180	16.9	.160	.030			.010	.010	.010						1900
2000	180	15.3					.010	.010							2000
2100	179	19.1					.010	.010	.010						2100
2200	178	21.0	.230	.050			.010	.010							2200
2300	183	22.8	.440	.230			.010	.010			.010	.010			2300
2400	183	28.6	.560	.220			.010	.010			.010	.010			2400
AVRG	183	17.6		.068				.004		.002		.002			AVRG

Table A-3

AMBIENT SO_2 CONCENTRATIONS - APRIL 4, 1981

GALLATIN AIR MONITORING NETWORK

GALLATIN STEAM PLANT — TENNESSEE VALLEY AUTHORITY — PRINT-DATE 04/10/81

STA 73 11 — AMBIENT AIR CONCENTRATIONS (PPM) — VALIDATED

811064 04/04/81 (NOVA)

PERIOD ENDG (CST)	PREV HR	WIND DIED	WIND SPEED	SO2 PEAK STA 1 (004) AA	SO2 AVG STA 1 (184) BA	SO2 PEAK STA 7 (656) AG	SO2 AVG STA 7 (239) BG	SO2 PEAK STA 6 (159) AF	SO2 AVG STA 6 (339) BF	SO2 PEAK STA 5 (261) AE	SO2 AVG STA 5 (681) BE	SO2 PEAK STA 8 (340) AH	SO2 AVG STA 8 (160) BH	PERIOD ENDG (CST)
0100	190		24.8	.360	.120			.010	.010	.010		.020	.010	0100
0200	195		23.4	.080	.010					.010				0200
0300	192		24.8	.290	.110									0300
0400	185		27.0	.370	.260							.010		0400
0500	186		25.0	.450	.240							.010	.010	0500
0600	184		22.5	.530	.290							.010	.010	0600
0700	186		22.0	.550	.300							.010	.010	0700
0800	193		24.7	.280	.070							.020	.020	0800
0900	189		28.9	.620	.160							.020	.020	0900
1000	190		28.7	.540	.140							.020	.020	1000
1100	200		25.5	.040	.010							.030	.020	1100
1200	193		24.2	.710	.090							.030	.030	1200
1300	184		26.7	.560	.190							.050	.030	1300
1400	184		26.3	.690	.300							.040	.010	1400
1500	184		30.0	.660	.350							.020	.010	1500
1600	186		33.1	.800	.240							.030	.020	1600
1700	200		25.9	.070		.010						.020	.010	1700
1800	238		15.7			.230	.030					.050	.020	1800
1900	282		10.9	.010		.020	.010					.010		1900
2000	200		11.6	.010	.010	.020	.010							2000
2100	220		13.7	.010	.010	.010								2100
2200	227		11.3	.010	.010									2200
2300	247		9.4	.020	.010									2300
2400	257		8.4	.020	.020									2400
AVRG	204		21.9		.125		.002						.010	AVRG

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Table A-4

GALLATIN STATION 1

SO_2 MONITOR CALIBRATION/AUDIT HISTORY

State of Tennessee Audit, February 18, 1981

Calibrator Setting (ppm)	Monitor Reading (ppm)	Difference (%)
0.074	0.075	+ 1.4
.183	.190	+ 3.8
.425	.435	+ 2.4
.831	.833	+ .2
-	0.150	+ 3.4*

TVA Calibration, February 19, 1981

Calibrator Setting (ppm)	Monitor Reading (ppm)	Difference (%)
0.192	0.205	+ 6.8
.860	.882	+ 2.6
-	0.150	+ 8.7*

TVA Calibration, March 5, 1981

Calibrator Setting (ppm)	Monitor Reading (ppm)	Difference (%)
0.192	0.200	+ 4.2
.860	.860	+ .0
-	0.150	+ 6.4*

TVA Calibration, April 16, 1981

Calibrator Setting (ppm)	Monitor Reading (ppm)	Difference (%)
0.192	0.202	+ 5.2
.860	.915	+ 6.4
-	0.150	+ 5.0*

*Estimated difference at level of excess on April 3-4, 1981, based on linear interpolation/extrapolation.

Appendix B

METEOROLOGICAL DATA

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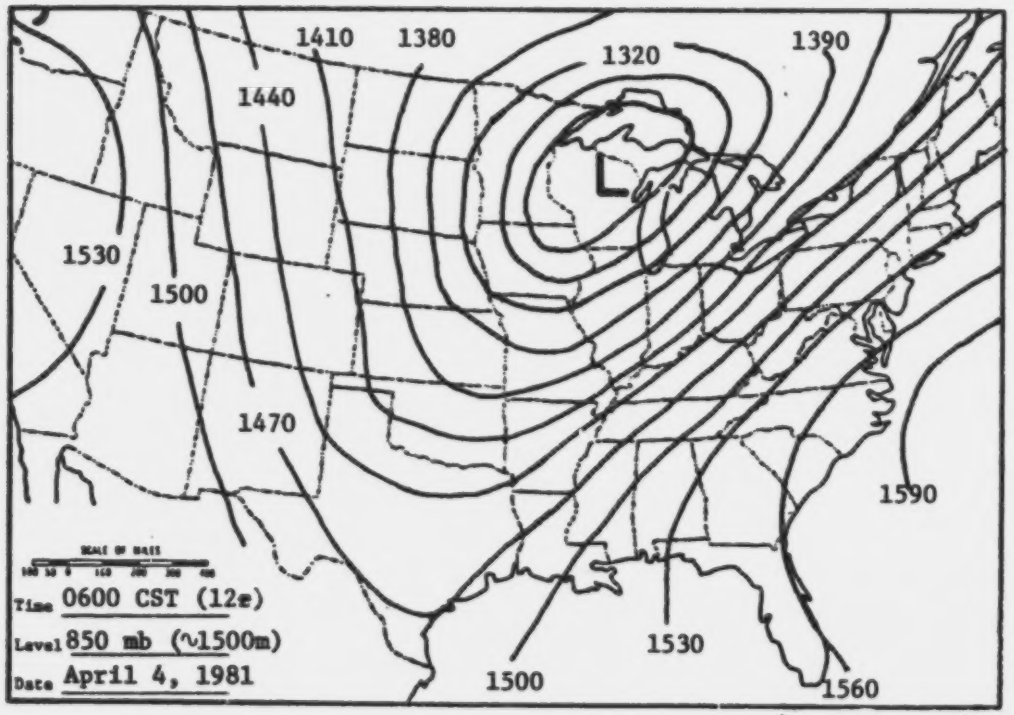

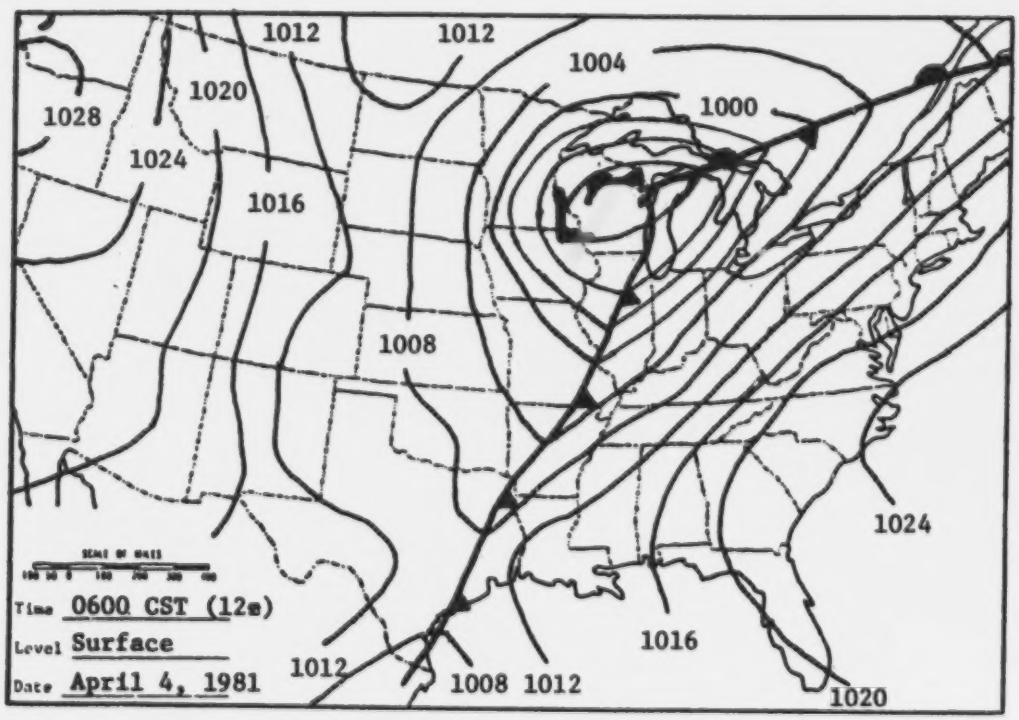

Figure B-1. SYNOPTIC WEATHER MAPS - APRIL 4, 1981

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Table B-1

METEOROLOGICAL TOWER DATA - APRIL 3, 1981

GALLATIN STEAM PLANT

HOUR ENDING (CDT)	61METER WINDS WIND SPEED (M/S)	WIND DIRECTION (DEG)	PERSISTANCE (%)	TEMP 61-METER (DEG C)	TEMP 10-METER (DEG C)	TEMP 1-METER (DEG C)
100	6.7	193	81	18.2	15.7	*****
200	5.6	182	94	16.5	14.1	*****
300	6.6	184	94	15.6	13.2	*****
400	6.4	170	100	15.9	12.6	*****
500	4.6	181	97	15.0	12.4	*****
600	4.6	181	81	14.7	12.3	*****
700	5.6	184	88	15.4	13.7	*****
800	7.7	193	81	17.1	17.0	*****
900	6.2	185	74	19.2	20.1	*****
1000	6.8	191	70	20.8	21.9	*****
1100	6.1	190	65	21.8	22.7	*****
1200	9.3	189	75	23.4	24.3	*****
1300	9.4	189	74	23.8	24.6	*****
1400	9.5	188	77	23.5	24.1	*****
1500	9.3	182	84	23.5	23.9	*****
1600	9.7	181	77	24.4	25.0	*****
1700	10.9	181	85	25.3	25.7	*****
1800	9.2	177	83	24.4	24.4	*****
1900	7.4	180	89	23.2	22.9	*****
2000	6.8	180	90	22.6	22.2	*****
2100	8.5	179	94	22.5	22.0	*****
2200	9.4	178	82	22.6	22.2	*****
2300	10.2	183	82	22.6	22.2	*****
2400	12.8	183	79	22.8	22.6	*****

* INDICATES LOST RECORDS

Table B-2

METEOROLOGICAL TOWER DATA - APRIL 4, 1981

GALLATIN STEAM PLANT

HOUR ENDING (CDT)	61METER WINDS WIND SPEED (M/S)	WIND DIRECTION (DEG)	PERSISTANCE (%)	TEMP 61-METER (DEG C)	TEMP 10-METER (DEG C)	TEMP 1-METER (DEG C)
100	11.1	190	80	22.6	22.4	*****
200	10.5	195	83	21.9	21.5	*****
300	11.0	192	81	21.3	21.1	*****
400	12.1	185	84	20.7	20.6	*****
500	11.2	186	84	20.2	20.1	*****
600	10.1	184	81	19.8	19.8	*****
700	9.8	186	79	20.1	20.3	*****
800	11.0	193	78	21.1	21.5	*****
900	12.9	189	76	21.6	22.1	*****
1000	12.8	190	70	22.3	23.0	*****
1100	11.4	200	77	22.7	23.5	*****
1200	10.8	193	65	22.6	23.2	*****
1300	11.9	186	75	22.3	23.2	*****
1400	11.8	186	82	23.6	24.2	*****
1500	13.4	184	80	24.9	25.3	*****
1600	14.8	186	77	25.5	25.6	*****
1700	11.6	200	45	22.1	22.1	*****
1800	8.3	238	35	17.6	17.9	*****
1900	4.9	282	34	15.6	15.9	*****
2000	5.2	200	86	15.7	15.9	*****
2100	6.1	229	76	16.1	15.6	*****
2200	5.1	227	91	16.1	15.3	*****
2300	4.2	247	84	15.9	15.3	*****
2400	2.9	257	75	15.8	15.4	*****

* INDICATES LOST RECORDS

BEST DOCUMENT AVAILABLE

Table B-3

RADIOSONDE TEMPERATURE PROFILE - APRIL 3-4, 1981

NASHVILLE, TENNESSEE

April 3, 1981

Time: 0600 CST

Height (m-AGL)	Temperature (°C)	Temperature Gradient (°C/100 m)
0	12.5	-
148	19.6	+4.80
344	20.0	+ .20
889	15.6	- .81
1334	12.3	- .74
1613	9.9	- .86

Time: 1800 CST

Height (m-AGL)	Temperature (°C)	Temperature Gradient (°C/100 m)
0	25.0	-
197	23.2	-0.91
999	16.0	- .90
1303	14.6	- .46
2081	10.8	- .49

April 4, 1981

Time: 0600 CST

Height (m-AGL)	Temperature (°C)	Temperature Gradient (°C/100 m)
0	20.0	-
163	18.6	-0.86
728	15.3	- .58
1294	11.5	- .67
1914	7.8	- .60

Time: 1800 CST

Height (m-AGL)	Temperature (°C)	Temperature Gradient (°C/100 m)
0	18.0	-
66	18.0	0.00
623	13.8	- .75
790	14.8	+ .60
1273	12.5	- .48
2161	6.6	- .66

Table B-4

RAWINSONDE WIND PROFILE - APRIL 3-4, 1981

NASHVILLE, TENNESSEE

April 3, 1981

Time: 0600 CST

Height (m-AGL)	Wind Direction (°)	Wind Speed (m/s)
0	180	3.1
52	201	12.9
346	208	15.4
649	216	17.0
946	215	16.0
1230	221	12.9
1499	239	11.8
1784	247	11.3

Time: 1800 CST

Height (m-AGL)	Wind Direction (°)	Wind Speed (m/s)
0	180	6.2
72	175	16.5
349	181	17.0
625	188	18.0
920	199	21.6
1248	209	24.2
1559	214	23.2

April 4, 1981

Time: 0600 CST

Height (m-AGL)	Wind Direction (°)	Wind Speed (m/s)
0	180	7.2
112	191	16.5
368	199	20.6
625	210	23.7
883	222	25.2
1144	228	25.2
1439	228	27.3
1734	227	28.8

Time: 1800 CST

Height (m-AGL)	Wind Direction (°)	Wind Speed (m/s)
0	210	7.7
71	223	12.9
336	233	17.5
610	242	21.6
879	240	22.7
1147	232	20.1
1416	231	24.2
1685	236	31.9

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Appendix C

SO_2 EMISSION DATA

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Table C-1

SULFUR DIOXIDE EMISSION INVENTORY DATA FOR

SO_2 POINT SOURCES WITHIN 10 KM RADIUS

OF GALLATIN STEAM PLANT

Source Name	UTM Source Location (km)		Estimated SO_2 Emission Rate (g/s)	
	Easting	Northing	Allowable	Actual
Globe Business Furniture	550.8	4029.2	120.7	0.1
Eaton Corporation	550.5	4026.3	2.0	<0.1
Sumner County Board of Education	Various	Various	14.4	0.3
Kraft Foods	549.3	4029.2	7.9	0.3
R. C. Owen Co.	550.8	4028.3	13.2	0.1
Gallatin Steam Plant	553.8	4018.9	See Table C-2	

Table C-2

GALLATIN STEAM PLANT

COAL ANALYSIS AND SO_2 EMISSIONS*

Coal Analysis

Date	Sulfur (%)	Btu/lb	SO_2 Emissions ($lb/10^6$ Btu)
April 3, 1981	2.8	11,910	4.5
April 4, 1981	2.8	12,100	4.4

Plant Operations Average Generation (MW)**

Date	Units 1-2	Units 3-4	Plant Total
April 3, 1981	225	235	490
April 4, 1981	227	257	484

Average SO_2 Emissions (g/s)**

Date	Units 1-2	Units 3-4	Plant Total
April 3, 1981	1304	1225	2529
April 4, 1981	1135	1313	2448

*Provided by TVA Technical Services Branch, Division of Fossil and Hydro Power.

**Expected generation and SO_2 emissions at capacity
Generation = 1256
SO_2 Emissions = 7135 g/s

Appendix D

PRELIMINARY MODELING ANALYSIS

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MEASURED EXCESS OF AN AMBIENT SO_2 STANDARD

PRELIMINARY MODELING ANALYSIS

Plant: Gallatin Steam Plant

Period of Measured Excess: From 1600 on April 3 to 1500 on April 4, 1981

Standard Exceeded: Primary (24-hour)

Monitor: 1

Location: X (east) = 0.19 km; Y (north) = 2.89 km
r (distance)= 2.90 km; θ (azimuth) = 4.0^{o}

Measured Average: 0.15 ppm

Plant Operation: The SO_2 emission rate from stack 1 and 2 was about 1200 and 1400 g/s, respectively. Estimates of corresponding exit velocities were about 11 and 12 m/s.

Meteorological Conditions: During this episode the average wind speed was about 9.4 m/s; the average wind direction was 187^{o} (blowing from) with a standard deviation of 5.4^{o}. The maximum hourly wind speed was about 13.5 m/s. Thus, the most significant meteorological features were the high wind speed and persistent wind direction.

Model Results: This episode was modeled by using the wind speed and direction measurements at the 61-m level on the Gallatin meteorological tower. Because either plume downwash (stack downwash can occur if the exit velocity does not exceed the wind speed at stack top by about 50 percent) or decreased plume rise is likely to occur at such high wind speeds, an effort was made to account for this phenomena by assuming that either the initial vertical dispersion was 25 m, or that the plume rise was decreased by 76 m. Depending on the specific assumptions, the estimated 24-hour average concentration was between 0.15 and 0.22 ppm at monitor 1. If these phenomena are ignored, the estimated 24-hour concentration at monitor 1 is 0.13 ppm.

Conclusion: Based on the modeling results and information about the prevailing wind direction, it appears that Gallatin Steam Plant was responsible for the measured SO_2 excess.